Biogenic Symposium December 9 to 10
Abstracts
Biogenic Emissions - Biosphere Atmosphere Exchange - Net Effects Symposium
December 9-10
DHS Auditorium
Sacramento California

December 9, 1999 - 8:15 am to 4:30 pm

8:15 *Biogenic emissions inventory development from a historical perspective*
Keynote Speaker, **Dr. Arthur M. Winer**

8:35- 12:05
Session I: Biogenic Emissions through Geographic Information Systems (BEIGIS)

Speakers	Presentation Topic
Dale Shimp (ARB)	Legal, regulatory, and scientific need for a California-specific BVOC inventory
Michael Benjamin (ARB)	General structure of BEIGIS and overview of inputs needed
Skip Campbell (ARB)	Compilation of GIS vegetation coverages
John Karlik (UCCE)	**Description and Assessment of California GAP Databases for use in Assembling BVOC Emission Inventories**

Accurate estimates of biogenic volatile organic compound (BVOC) emissions require reliable assessments of plant species composition and dominance in the form of contemporary vegetation databases, especially for natural plant communities. The GAP databases are so-named because they were developed as part of the national Gap Analysis Project, with the primary goal of identification of gaps in the preservation of species and habitats. The GAP databases and corresponding maps are perhaps the most detailed representations of plant species distributions ever produced for much of the United States. In California, GAP databases have been prepared for each of the 10 regions of flora identified in *The Jepson Manual*. The primary sources for these data are satellite and high-altitude aircraft imagery, with limited field-based data incorporated from the vegetation type maps of the 1930's. To evaluate the suitability of the GAP database for use in assembling a BVOC emission inventory for California, we conducted a stratified random sampling field study to quantitatively assess the assignment of plant species identities and coverages in selected GAP polygons. In 1996-1997, four polygons containing chaparral vegetation and four polygons of woodland vegetation were investigated in San Diego County as part of the SCOS-97 campaign, using field protocols recommended by the California developers of GAP. For polygons dominated by trees, three sample elements were chosen per polygon, each consisting of two perpendicular belt transects 6 m wide and 500 m long. In addition to noting the species identities along each transect, the trunk diameters and crown dimensions of trees were recorded. For polygons dominated by shrubs, four sample elements were chosen per polygon, each consisting of two perpendicular 300 m line transects. Results from the field assessment of the GAP database for San Diego County revealed that the species listed by GAP accounted for 65-75% of the relative cover in the polygons studied. About 60% of the species listed by GAP were found in high enough proportions in the field surveys to justify their listing. On balance, the GAP GIS database for San Diego County was judged to be a useful source of species composition and dominance information for BVOC emission inventories, if supplementary data for leafmasses of those species are available. In 1999, our validation field studies shifted to the southern Central Valley of California, where nine GAP polygons found on the valley floor and the surrounding

mountains were assessed. Preliminary results from this region indicate a degree of agreement between the GAP assignments and our field identifications similar to that found in San Diego County.

Ned Nikolov (ORNL)	Development of leaf area index (LAI) databases from satellite imagery
John Karlik (UCCE)	**Estimation of Leafmass Densities for BVOC Emissions Inventory Development for California Airsheds**

To assemble reliable biogenic volatile organic compound (BVOC) emissions inventories for California airsheds, quantitative, spatially resolved, species-specific descriptions of leafmass are required. Measurement methods for estimating leafmasses may be divided into three categories: direct, allometric, and indirect. Direct measurement methods include various forms of sampling, either in two or three dimensions, and also include whole-tree harvest and leaf removal. These methods are time- and labor-intensive and therefore only feasible for small sample sizes, but can yield data of high precision and accuracy. Allometric measurement methods define relationships between leafmass and more-easily measured biometric parameters, for example stem diameter. Field sampling is necessary to develop allometric equations and empirical coefficients, which are usually specific to individual plant species. Indirect measurement methods include measurement of light interception or spectral reflectance at various wavelengths. These methods have potential for development of leafmass density information over wide geographic areas because spectral data can be acquired through remote sensing technologies, such as satellite-based instrumentation. Relationships are complex between various kinds of spectral data and leafmass, but leaf area index values derived from spectral data may provide a verifiable link for describing leafmass densities of California's plant communities. Quantitative values for leafmass density have been compiled from the literature from studies conducted in California and from studies of plant communities in other regions of the world, including those with Mediterranean climates. Leafmass densities and leaf area indices for urban trees have also been determined experimentally through whole-tree harvests in our recent and current ARB-funded projects. However, additional field measurements of leaf area index and leafmass density are needed for California plant communities.

Arthur M. Winer (UCLA)	**Measured Isoprene Emission Rates of Plants in California Landscapes: Comparison to Estimates from Taxonomic Relationships**

Isoprene emission rates of 64 plant species found in California's urban and natural landscapes were measured using a flow-through chamber enclosure technique. Species were selected to provide data for previously unmeasured species and to test estimates of isoprene emission rates based upon taxonomic relationships as proposed by Benjamin et al. (1996, Atmospheric Environment 30: 1437-1452). Branch-level isoprene emission rates ranged from undetectable for 47 species, to 54 ug g^{-1} h^{-1} for California black oak. Isoprene emission rate estimates based on taxonomy agreed well with our measurements for species within the same genus, with the exception of the *Quercus* genus for which a wide range of isoprene emission rates have been reported. As expected, family-level estimates based on taxonomy showed greater deviation from our measured values than did genus-based estimates. The data developed in the present study support use of a taxonomic predictive methodology, especially if previous measurements within specific families, sub-families, and genera are extensive, and the results of such assignment are treated with proper caution. A taxonomic approach may be most useful where plant

species in natural and urban landscapes are numerous, such as in California, where no experimental measurements are available for thousands of species.

Michael Benjamin (ARB)	Discussion of BEIGIS output, including comparison with other inventories
All	Round table discussion of future work needed

All presentations will last 20 minutes including 5 minutes for questions and the roundtable will have 40 minutes.

1:00 to 4:00
Session II: Databases for Fire Prediction, Wild Land Management, Urban Forestry, Ecosystem Health, and Biogenic Emissions

Speakers   **Presentation Topic**
John Karlik (UCCE)
Paula Pepper (UCD)   **Urban Tree Growth: Predicting Dimensions, Leaf Area and Foliar Biomass Over Fifty Years**

Results of testing 5 leaf area estimation methods on 60 open-grown trees, representing 4 species, during 1996 and 1997 showed that image analysis of digital photographs produced the most accurate leaf area estimates (±10%). Subsequently, street trees of known age (1 to 50 years old) were randomly sampled in Modesto and Santa Monica, California during 1998 and 1999. Dimensional data were collected and the digital leaf area method was applied to estimate leaf area for each of the 40 species sampled. Regression equations for predicting dbh, tree height, crown height, crown diameter, crown projection leaf area, and foliar biomass for each species over life spans of fifty years were developed. Leaf area to dry weight ratios were calculated for tree species sampled in Santa Monica. Comparisons of species grown in both locations show significant differences in total leaf surface area, reflecting the difference in Modesto and Santa Monica street tree management and planting locations of the trees.

Mark Rosenberg (CDF)   **Consistent, Detailed & Up-to-Date GIS Based Vegetation Data with Sufficient Spatial Scale & Attribution for the state of California**

Many different vegetation maps have been developed over the last 10 years in California however few cover the entire state and those that do cannot provide the spatial detail needed to address key questions related to air quality, forest health, habitat assessment and vegetation fuel loading. Many more detailed vegetation maps have been developed for smaller areas however each uses its own unique classification system and method and many do not carry the critical stand structure information necessary to address these critical resource issues. Differences in mapping classification systems, attributes, and scale make it difficult to monitor and assess vegetation condition across a mixed ownership, multi-jurisdictional area. Data consistent across jurisdictional boundaries will facilitate comparable estimates of fuels, habitat, timber and other resources and support more effective fire protection, planning and regulation of California wild lands. Through the 1990 Memorandum of Understanding for Cooperative Forestland Mapping, CDF and the USFS have developed a standard approach to vegetation mapping that provides seamless data across all ownership; facilitates cooperative planning and decision making; promotes interdisciplinary communication regarding California vegetation resources; and avoids duplication of efforts. This methodology includes a coordinated schedule for map

updating every 5 years. CDF and the USFS seek to expand this methodology to the entire State through a multi-agency collaborative effort which will identify minimum standards and guidelines for new mapping efforts within California and outline a cooperative approach to meeting these standards in the future.

Jim Troehler (CDF) **CDF Fire Protection Database - An Enterprise wide Solution**

As a part of the California Fire Plan, The California Dept. of Forestry and Fire Protection (CDF) has developed an enterprise wide GIS solution which provides data access and exchange services to CDF and participating agencies in support of departmental pre-fire planning and fire protection responsibilities. This system serves and maintains tabular and GIS based data and software and ensures the most accurate and up-to-date information is available for fire prevention, fire-planning and fuels management. Critical GIS based data themes such as fire history, fire ignitions, vegetative fuels, weather, housing, transportation and other assets at risk information are available to fire protection staffs through an Oracle based Spatial Database Engine (SDE). The client-server architecture allows field users to update, maintain and correct spatial data themes stored in a centralized location, reducing data management challenges and allowing Department and cooperating agencies easy and efficient access to data.

Mark Poth (USFS)
Ruri Imamura (UCSF)
Qingfu Xiao (UCD) **Using High Resolution Remote Sensing Data To Characterize Urban Forest Tree Species Composition**

California's urban forests provide habitat for over 90% of the state's population and their impact on human and environmental health is a significant concern. Urban forests contain a diverse mix of tree species (over 200 species in most cities) arranged in sometimes heterogeneous patterns. Characterizing structure and species composition is fundamental to estimating BVOC emissions and other impacts of urban forests on air quality. However, the costs associated with methods relying on aerial photography and field sampling have been high. New technologies provide the capability to acquire and process multispectral data at very high resolution. With these technologies it may be possible to provide more accurate estimates of tree cover and urban forest structure at lower cost. Also, they may make it possible to detect differences among certain types of species and their leaf areas. In this study, we use remote sensing data from the Airborne Visible InfraRed Imaging Spectrometer (AVIRIS) and Geographic Information System (GIS) techniques to identify tree species in the City of Modesto, California. The unmixing method was used for analysis of the high spectral remote sensing data. Initial results show that we can accurately distinguish different types of trees in urban forests (e.g., deciduous, broadleaf evergreen, conifer). At the individual tree species level, 5 of 18 tree species were accurately classified greater than 80% of the time, and another 6 of 18 were accurately classified greater than 60% of the time. The procedures to conduct this analysis are not site dependent and consequently, they can be applied to other locations. These study results can be directly used for forest management and urban ecosystem research, as well as for air quality, energy, and hydrology analyses.

Professor Arey/
Anni Reissell (UCR)
All Round table discussion of future work needed

All presentations will last 25 minutes including 5 minutes for questions and the roundtable will have 40 minutes.

Poster Session will be at 5:00 pm
Presenter   Presentation Topic

Reggy Spalding (UCD)   **Air Pollution and Biota**

December 10, 1999
8:30-12:00
Session III: Modeling Tools for Fire Prediction, Wild Land Management, Urban Forestry, Ecosystem Health, and Biogenic Emissions

Speakers	Presentation Topic
Tony VanCuren (ARB)	Overview of fire simulation and work at Lake Tahoe
Tom Pierce (EPA)	Biogenic Emissions Inventory System (BEIS) III
Alex Guenther (NCAR)	**The GLObal Biogenic Emissions and Interactions System (GLOBEIS)**

The GLObal Biogenic Emissions and Interactions System (GLOBEIS) GLOBEIS is a flexible modeling framework that provides quantitative estimates of the chemical interactions between the biosphere and the atmosphere. GLOBEIS is not limited to any particular grid system or landcover characterization scheme and so can be used for modeling cases ranging from the region surrounding a flux tower to the entire earth system. GLOBEIS has a modular form and has been used extensively to investigate the sensitivity of emission model results to changes in various model components. An overview of GLOBEIS is given and current plans for extending this modeling system and evaluating the results are discussed.

Christine Wiedenmyer (UT)   **Land Cover Characterization in Texas**

To improve the understanding of chemical emissions and atmospheric chemistry in Texas, recent efforts have been made to improve the biogenic emission inventories there. The University of Texas at Austin has created a land cover and vegetation database for the state to obtain better biogenic emission estimates. This database is the compilation of several smaller projects completed during the past three years. Available electronic data have been aggregated with Geographical Information Systems (GIS) to create a mapping of land use and land cover classifications throughout Texas. Tree species and diameter distributions have been collected in rural and urban areas. These field data were used to assign species and leaf density distributions to each land cover classification assigned to the state. The Texas data have been joined with available data for surrounding states and Mexico, so that a biogenic emissions inventory can be created for a regional modeling domain.

Christian Seigneur (AER)   Simulations for BEIS II

Gregory MacPherson (UCD)   **Benefit-Cost Analyses for Urban Forests**
This presentation reviews a benefit-cost analysis of Modesto's municipal urban forest. It answers the question: *Do the accrued benefits from Modesto's urban forest justify an annual municipal budget that exceeds $2 million?* Cost data were obtained for FY 1997-98 from the Community Forestry Division. Tree related expenses captured by other departments for sidewalk and curb repair, leaf clean-up, and claims were also included. Annual benefits were estimated for 1998 using tree information from the city tree inventory and field-based estimates of tree dimensions and leaf area. The tree population was "grown" for one year and benefits estimated for pollutant dry deposition, net energy savings, net atmospheric CO_2 emission reduction, stormwater runoff reduction, and aesthetic and other benefits. Prices were assigned to each benefit through direct

estimation and implied valuation of benefits as environmental externalities. Results indicate that the benefits residents obtain from Modesto's 91,179 public trees exceed management costs by a factor of nearly 2. In FY 1997-98 Modesto spent $2.6 million for urban forestry ($14.36/resident, $28.77/tree), and 74% of this amount was for mature tree care. Total annual benefits from Modesto's urban forest were $4.95 million ($27.12/ resident, $54.33/tree). Net benefits were $2,329,900 ($12.76/resident, $25.55/tree). Annual air pollutant uptake was 154 metric tonnes (3.7 lb/tree) with an implied value of $1.48 million ($16/tree). Aesthetics and other benefits had an estimated value of $1.5 million ($17/tree). Building shade and cooler summertime temperatures attributed to street and park trees saved 110,133 MBtu, valued at $870,000 (122 kWh/tree, $10/tree). Smaller benefits resulted from reductions in stormwater runoff (292,000 m^3 or 845 gal/tree, $616,000 or $7/tree) and atmospheric carbon dioxide (13,900 t or 336 lb/tree, $460,000 or $5/tree). Due to the population's relatively even-aged structure and heavy reliance on mature Modesto ash for benefits, management strategies are needed that may reduce net benefits but increase diversity and stability. A similar analysis is now in progress for the City of Santa Monica.

All   Round table discussion of future work needed

All presentations will last 30 minutes including 5 minutes for questions and the roundtable will have 30 minutes.

1:00 to 4:30
Session IV: Validating Simulation Results

Speakers	Presentation Topic
Charles Smith (EPA)	**VOC radiocarbon measurements during SCOS97 and emissions inventory validation**

Radiocarbon (^{14}C) measurements provide an estimate of the fraction of carbon in a sample that is biogenic. In September 1997 during SCOS97 a series of 3-h canister samples of ambient air were collected at the Azusa air monitoring station during morning and afternoon periods. The fraction of VOC that was biogenic ranged from 0 to 38% for the 10 samples on which ^{14}C measurements were performed, with a mean value of 15 %. GC-FID measurements were also performed on the same samples. The presentation will give details of the results along with a description of the technology involved in the sampling, sample preparation, and ^{14}C analysis (by accelerator mass spectrometry). In addition an example of how similar measurements performed in Atlanta were related to emissions inventories will be given.

Rei Rasmussen (OGI)   **Oxygenated Hydrocarbons in Rural Air Masses**

The VOCS in clean air are predominantly oxygenated hydrocarbons. There is very little acetylene, ethylene, benzene, toluene, xylenes (BETX) etc. in clean tropospheric air, and methane, ethane and propane are geophysical constituents. Near or within forests and woodlands; isoprene, MBO and the terpenes, typically alpha pinene, are the major identified biogenic VOCS. In addition several specific oxidation products from these biogenics are measured. The bulk of the VOCS measured in the atmosphere outside of urban areas is unidentified. Currently, we measure by GC-MS 80 oxygenated hydrocarbons in the atmosphere from acetaldehyde to decanal, about 40 are very common. We believe that these compounds account for some of the unidentified VOCS that characterize rural -air. The composition of clean air is in sharp contrast to urban air which is dominated by fresh and residual hydrocarbon emissions. A three part cryo- collection procedures

is used to obtain enough of these ubiquitous oxygenated compounds in the rural air at the Duke Forest in RTP, NC so they can be characterized for subsequent carbon isotope measurements. Many of these carbonyls, ketones , alcohols and esters are "under" the very dominant hydrocarbon footprint typical of the conventional GC-MS TIC chromatograms of urban air. Cryo-fractionation of the whole air recovered directly from the atmosphere or from the air in SUMMA canisters after their TO-14 and PAMS hydrocarbon speciation provides a robust means of separating the oxygenates from the overburden of hydrocarbons. The oxygenated species we are measuring are very reactive with ozone and OH, are readily soluble in water and absorbed onto aerosols. The data will be presented and discussed.

George Klouda (NIST)   **Collecting Atmospheric Volatile Organic Compounds from 2.4 m[3] of Air to Enhance the Sensitivity of Chemical and Carbon-Isotope Measurements**

A field method has been evaluated for isolating oxygenated hydrocarbons and hydrocarbons from up to 2.4 m[3] of air for chemical and carbon isotope (^{14}C, ^{13}C) measurements. Air is processed through a column of LiOH to remove CO_2 and then through a series of cryotraps to separate water, oxygenates, and hydrocarbons based on their vapor pressure and water solubility. The two nearly pure VOC fractions are reduced in volume to 10's to 100's of microliters and finally each diluted with 14 L of zero air for transfer to analytical systems. Only a small portion (ca. 10%) of each VOC fraction is needed for chemical characterization by gas chromatography flame-ionization (GC-FID) and mass-spectrometry (GC-MS) detection and stable carbon isotope ($\delta^{13}C$) analysis of individual compounds by gas chromatography isotope ratio mass spectrometry (GC-IRMS). The ability to independently chromatograph these highly concentrated VOC fractions yields greater sensitivity and resolution needed for identifying and quantifying VOC. The remainder of the sample is processed for ^{14}C measurement by accelerator mass spectrometry (AMS) with an improvement in ^{14}C sensitivity through increased sample size and a lower relative chemical blank from that previously reported. This method is expected to yield more precise biogenic estimates of these two VOC classes with a higher level of confidence than canister-based methods.

Allen Goldstein (UCB)   **Introduction to Blodgett Forest & separating the impacts of biogenic and anthropogenic VOCs on atmospheric chemistry**

We have established a measurement site in a ponderosa pine plantation to study the exchange of radiatively and chemically active trace gases between the forest and the atmosphere (including CO_2, H_2O, VOCs (talk by Schade), O_3, (talk by Panek) and NO_y (talks by Cohen and Dillon)), and to understand their influence on regional atmospheric chemistry. The site is located next to Blodgett Forest, on land owned by Sierra Pacific Industries, in Georgetown, California, 38°53'42.9"N, 120°37'57.9"W, 1315 m elevation. This talk will provide an overall introduction to the project, and will then focus on separating the impacts of biogenic and anthropogenic volatile organic compounds (VOCs) on regional atmospheric chemistry. Measurements of C_2-C_{10} VOCs were made hourly above a ponderosa pine plantation using an automated in-situ dual-channel GC-FID system throughout July 1997, from July through October 1998, and fluxes were measured with a relaxed eddy accumulator from July through September 1999. Factor analysis and observed temporal patterns were used to categorize sources for measured compounds as biogenic or anthropogenic or both. Compounds that were clearly biogenic included methylbutenol, isoprene and its oxidation products (methacrolein and methyl vinyl ketone), and terpenes (α-pinene, 3-carene, d-limonene). Other compounds were partially biogenic, including acetone, ethene, propene, hexanal, acetaldehyde, and methanol. The clearly biogenic compounds accounted for 70% of the total hydroxyl radical (OH) loss rates under mean midday conditions. The most important single compounds were isoprene (33%) and methylbutenol (21%).

These two compounds were dominant under all conditions, including the coldest and most polluted days. Under the most polluted conditions, acetaldehyde became very important, accounting for 13% of the total. Total OH loss rates were highly correlated with temperature because emissions of biogenic compounds, which dominate OH loss, are strongly temperature dependent. Much of the research on biogenic volatile organic compounds has focused on isoprene and terpenes. Our results suggest that quantifying and understanding factors controlling biogenic emissions of other compounds such as methylbutenol, acetone, hexanal, methanol, and acetaldehyde are critical for improving our understanding of regional and global photochemistry.

Gunnar Schade (UCB) **Fluxes and abundance of biogenic hydrocarbons above a ponderosa pine plantation in the Sierra Nevada mountains**

We measured canopy scale fluxes of biogenic hydrocarbons above a young ponderosa pine plantation with a gradient technique in 1998, and with a newly developed relaxed eddy accumulation technique in 1999. Fluxes are dominated by 2-methyl-3-buten-2-ol (MBO) with 2-3 mg C m-2 h-1 during the daytime. MBO emission follows the light- and temperature algorithms described for isoprene but also shows a seasonal variation with a maximum during the highest activity levels of the pine trees. Monoterpene emissions are 10 times lower than MBO emissions and are mostly driven by ambient temperatures. However, during times of rain or extreme dryness, humidity exerts an influence on those emissions stronger than temperature. Air chemistry at this site is almost completely dominated by biogenic hydrocarbons, including isoprene. Though isoprene is not emitted to a substantial amount at the site itself, its ambient mixing ratios and those of its oxidation products suggest that there are isoprene sources upwind the site in the SW, most significantly a band of oak trees in the Sierra Nevada foothills. Comparisons between the isoprene oxidation products and regional ozone levels indicate that up to 60% of the ozone could be derived from isoprene oxidation.

Ron Cohen (UCB) **New Approaches to observing atmospheric nitrogen oxides: LIF detection of NO_2 and thermal-dissociation-LIF detection of peroxynitrates, alkyl nitrates and HNO_3**

We describe new approaches to observing NO_2 and closely related NO_y compounds, with examples from field campaigns at the UC Blodgett forest research station and at Cornelia Fort in Nashville, TN. The core of our new approach is the Berkeley laser-induced fluorescence (LIF) instrument. This instrument is capable of routinely making *in situ* observations of NO_2 that are accurate ($\pm5\%$, 1σ), sensitive (15 ppt/10 sec at S/N=2) and free from artifacts to below 1ppt. The instrument is portable; it weighs less than 150kg, consumes less than 2kW, and it operates autonomously for periods of days to weeks with little maintenance. The instrument is capable of 10Hz measurements necessary to measure fluxes by eddy-correlation and is designed for use on research aircraft. We have recently added a second channel to this instrument that uses a heated inlet to dissociate compounds such as PAN or HNO_3 into NO_2 and a companion radical. The NO_2 fragment is then detected by LIF. Laboratory experiments demonstrating capability to detect N_2O_5, peroxynitrates, alkyl-nitrates and HNO_3 will be presented. Preliminary results from a field campaign completed in mid-November '99 will be presented.

Don Durzan (UCD) **Visualization of NO Production in Plants under Stress**

Nitric oxide (NO) is now considered an emission from all plants. My lab has adapted a microscopic method to visualize NO production at a detection limit of 5 nM in stomatae,

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tissues and within live cells. In the presence of nitrate, emissions were increased nonenzymatically with a NO donor, and blocked by enzyme inhibitors of a putative plant NO synthase (NOS). The latter observation is especially noteworthy because the source of NO was not necessarily nitrate but rather the amino acid L-arginine. Together with arginine, oxygen is the substrate for NOS. From this observation, a citrulline-NO cycle was postulated as a stress-induced reaction that takes over from the default metabolism of arginine. Our test systems involved cells and tissues from conifers: *Araucaria* (Santa Catarina, Brazil), Norway spruce (Finland), *Taxus brevifolia* (Davis), and angiosperms: *Arabidopsis* mutants (Brazil) and *Kalanchoë* (Portugal) (e.g. Magalhaes et al. 1999 Physiol. Plant Mol. Biol. 5: 115-125). All plant parts produced NO, but levels varied with stage of development and the nature of the stresses applied: e.g. drought, water-logging, micro and hypergravity, etc (Pedroso et al. 1999 in press). The NO produced internally leads to the loss of DNA in chloroplasts. The toxic reaction product of NO e.g. peroxynitrite, nitrosylates cell regulatory proteins and may also cause programmed cell death. *This is commonly seen as the browning of tissues and abscission of plant parts.* This model is based on a model for programmed cell death (apoptosis) in plants (Havel and Durzan 1996 Botanic Acta 109: 268-277, Durzan et al. 1999 Acta Astronautica 42: 455-463). Results indicate that models for the health of plants and their contributions to the nitrogen cycle and changes in air quality need to be modified to include internal sources of NO that are nonenzymatic and enzymatic. In the absence of successful stress repair mechanisms, internal NO damage may lead to apoptosis at unit gravity and in simulated space environments. NO production by plants so far tested appears responsive to partial control by NOS inhibitors.

Mike Dillon (UCB)   **Quantifying anthropogenic influences on the atmospheric chemistry of the western Sierra: A background to assessing the role of biogenics**

We analyze two seasons (Summer '97 and '98) of measurements of anthropogenic hydrocarbons, NO, NO_2, NO_y, O_3, winds and temperature obtained in California's Central Valley and in the foothills of the Sierra Nevada. Our own measurements were obtained 75 km NE of Sacramento in a Sierra Pacific Co. Ponderosa Pine Plantation near the University of California Blodgett Research Forest. The measurements show that in the summer, the Blodgett forest site is characterized by an regularly repeated diurnal cycle in the winds. This cycle produces an extremely regular cycle in atmospheric composition. For most of the daylight hours, upslope winds bring air from the Central Valley into the foothills while the evening brings a wind reversal conveying clean air from the high Sierra. Concentrations of nitrogen oxide radicals and anthropogenic hydrocarbons are quite low during the clean periods with typical NO_x values below 400 ppt and anthropogenic hydrocarbon levels similar to the cleanest values measured at remote sites of similar latitude. These measurements and CARB observations obtained in Sacramento (Del Paso Manor) are analyzed simultaneously to characterize some of the key the factors—transport, diffusive mixing, OH abundance, and NO_y deposition rates--controlling atmospheric composition in the foothills of the Sierra.

Jeanne Panek   **Ozone Deposition to a Sierra Nevada Ponderosa Pine Ecosystem: Patterns and Controls**

Ozone levels in the Sierra Nevada Mountains are high enough to cause documented stress in mid- and high elevation forests. Ponderosa pine is one of the most sensitive species to ozone stress. To

assess the factors controlling ozone deposition to the forest and to study the forest response, we established a research site in a ponderosa pine plantation approximately 75-km northeast of Sacramento (Blodgett Forest, Georgetown CA, 1315 m). The site is affected by a strong diurnal ozone pattern with high concentrations in upslope flow during the day and lower concentrations during downslope flow at night. Two growing seasons of measurement—one very wet and one very dry—have provided insights into the factors controlling ozone deposition to the forest and resulting patterns of ozone flux. From June to September 1997 and May to November 1998 we continuously measured O_3, CO_2, and H_2O concentrations and O_3, CO_2, and H_2O fluxes by eddy covariance. Environmental parameters such as wind direction and speed, air temperature and moisture, net and photosynthetically-active radiation, soil temperature and moisture, and pine needle temperature were also monitored. Ozone deposition velocity, ozone flux normalized by ozone concentration, was strongly controlled by canopy conductance, which was in turn controlled primarily by soil moisture, vapor pressure deficit, and air temperature. We observed canopy conductance to be highest early in the growing season and early in the day. Because ozone flux is controlled by canopy conductance, we observed that peak ozone flux occurred in the early summer, while peak ozone concentrations occurred in the late summer. Furthermore, daily peak ozone flux preceded peak ozone concentrations by 2-4 hours. Ozone concentration and ozone deposition have significantly different temporal patterns due to this daily and seasonal decoupling, thus ozone concentration—widely used as an ozone exposure metric for crops and trees— is not necessarily a good determinant of ozone uptake by vegetation in California's Mediterranean climate. Soil and atmospheric moisture are strong controllers of canopy conductance and ozone deposition, therefore anticipated changes in California's climate can be expected to have a strong influence on the uptake of ozone by Sierra Nevada forests.

All   Round table discussion of future work needed

All presentations will last 20 minutes including 5 minutes for questions and the roundtable will have 30 minutes.